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Ministerie van Infrastructuur en Waterstaat

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Framework for Assessing Ecological and Cumulative Effects – 3.0: Description and assessment of cumulative effects resulting from the implementation of the 2030 Roadmap for Offshore Wind Energy

Part C: Summary

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The Framework for Assessing Ecological and Cumulative effects 3.0 (2019) consists of:

Part A
Framework for Assessing Ecological and Cumulative Effects for the roll-out of offshore wind energy 2030, KEC 3.0-2019
Part A: Methods

Part B
Cumulative effects of impulsive underwater sound on marine mammals,
TNO 2014

A first approach to deal with cumulative effects on birds and bats of offshore wind farms and other human activities in the Southern North Sea,
IMARES 2015

Framework for Assessing Ecological and Cumulative Effects – 2018. Cumulative effects of offshore wind farm construction on harbour porpoises, F. Heinis, HWE, C.A.F. de Jong, S. von Benda-Beckmann & B. Binnerts, TNO, 2018

Cumulative effects of offshore wind farms: loss of habitat for seabirds. Update for five seabird species until 2030, J.T. van der Wal, M.E.B. van Puijenbroek, M.F. Leopold, WMR 2018

Mitigation measures for bats in offshore wind farms. Evaluation and improvement of curtailment strategy, M. Boonman, Bureau Waardenburg, 2018

Update of KEC bird collision calculations in line with the 2030 Roadmap, Dr. A. Gyimesi, *ir.* J.W. de Jong, Dr. A. Potiek, E.L. Bravo Rebolledo MSc, Bureau Waardenburg 2018

Memorandum: Adding OWEZ and PAWP to the KEC 3.0 calculations, Dr. A. Gyimesi & J.L. Leemans, Bureau Waardenburg, 2018

Memorandum on Workshop dd. 12 July 2018, E.L. Bravo Rebolledo & A. Gyimesi, Bureau Waardenburg, 2018

Part C
Framework for Assessing Ecological and Cumulative Effects Description and assessment of the cumulative effects resulting from the implementation of the 2030 Offshore Wind Energy Roadmap
Part C: Summary

Relationship between parts A, B and C

Part A of the KEC report provides the conceptual framework for the approach to ecology and accumulation, and describes its implementation for offshore wind energy. Part A replaces previously published versions. The substantive reports (in Part B) further elaborate the substantive methods and models used, and include the calculations for the roadmap as made with the models. New reports have been added to Part B.
Part C provides an executive summary of the substantive reports and states the conditions required for the implementation of the 2030 Roadmap. Part C is new by comparison with previous versions.

Contents

1 Introduction

1.1 Background

There has been a need to describe and assess the effects of human activities on natural ecosystems since at least the 1970s. It was realised in the 1980s that it is not enough to describe and assess the effects of specific proposals and activities but that it is also necessary to examine whether the effects of various different activities can accumulate to produce larger or more damaging ecological or environmental impacts.

Since 2005, the Dutch government has received development consent applications for offshore wind farms that require a decision about how to assess not only the effects on the marine ecosystem of the separate wind farms but also the cumulative effects with other wind farms and in combination with other activities. Given a number of issues, including knowledge gaps about the cause–effect relationships, the presence of marine species and the resulting mandatory application of the precautionary principle, the assessment led to the imposition of restrictions on the development of offshore wind power and to a number of mitigation measures.

On the basis of the knowledge gaps identified, research programmes have been established (Ecological Monitoring Shortlist 2010-2011, Follow-up to Implementation of Master Plan 2012-2015, Offshore Wind Energy Ecological Programme (WOZEP[1])). Other countries have also recognised the effects (cumulative and otherwise) of offshore wind farms and have conducted extensive research in recent years.

The 2030 Offshore Wind Energy Roadmap was[2] published in March 2018. In addition to the wind farms to be built through to 2023, this also includes the scheduling and locations of the offshore wind farms through to 2030.
In the North Sea Policy Document 2016-2021, which is an integral part of the National Water Plan 2016-2021[3], the Dutch government has committed itself to drawing up and applying a framework for ecological and cumulative effects. This underlying Framework for Ecological and Cumulative Effects fulfils that commitment. Since January 2017, the inclusion of cumulative effects in plans and projects has also been implemented in Dutch legislation in Article 7.23(1)(f) of the Environmental Management Act.

1.2 Development of offshore wind energy

In September 2013 it was agreed in the SER Energy Agreement for Sustainable Growth to increase the proportion of energy generated from renewable sources in the Netherlands to 14% in 2020 and 16% in 2023. Specifically for offshore wind farms, it has been agreed that a total of 4,450 megawatts (MW) of installed capacity must be in place by 2023. In the Energy Agenda in December 2016, the government set out its decision that the offshore wind energy project would be expanded after the construction of the wind farms already planned in the North Sea.

[1] https://zoek.officielebekendmakingen.nl/kst-33561-26.html (in Dutch) and https://www.noordzeeloket.nl/en/functions-and-use/offshore-wind-energy/
[2] https://zoek.officielebekendmakingen.nl/kst-33561-42.html (in Dutch)
[3] https://zoek.officielebekendmakingen.nl/kst-31710-45.html (in Dutch)

On 27 March 2018, the Minister of Economic Affairs and Climate sent the '2030 Offshore Wind Energy Roadmap' to the Lower House of Parliament[4].
That roadmap includes plans for wind farms with a total capacity of at least 10,600 megawatts in 2030. The wind farms in the wind energy areas Ten noorden van de Waddeneilanden, Hollandse Kust (west) and IJmuiden Ver (see below) will go into operation between 2024 and 2030.
This KEC 3.0 will be used to further shape the provisions of the site decision for the construction and operation of wind farms in the 2030 Roadmap.

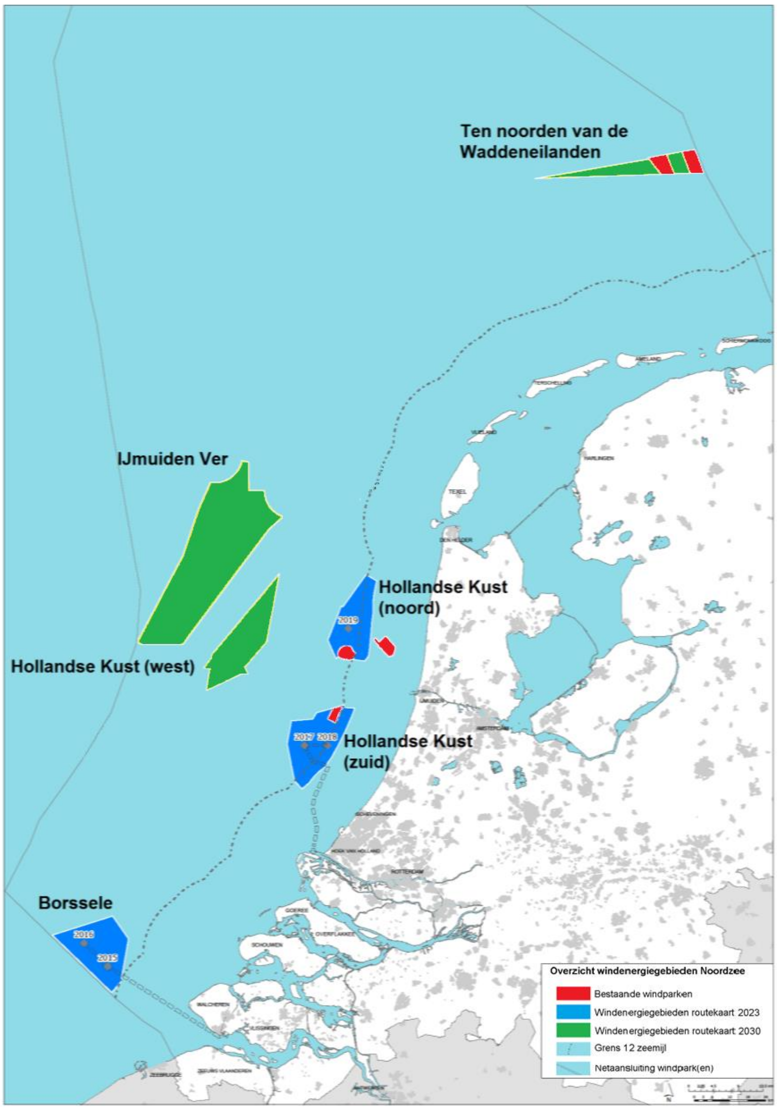

Figure 1 Location of wind energy areas prior to 2030

4 https://zoek.officielebekendmakingen.nl/kst-33561-42.html (in Dutch)

1.3 Part C of the Framework

Parts A and B of this Framework for Assessing Ecological and Cumulative Effects (KEC 3.0, 2019) show how the decisions were made about the species, populations and activities to be included in the assessment of cumulative effects and how these effects should be identified and described (and, where appropriate, the models to be used to do this). More specifically, Part A includes information about how cumulative effects of offshore wind energy activities should be addressed. Part B includes calculations relating to the requirements for offshore wind energy from the 2030 Roadmap in accordance with the methodology described in Part A of this framework. The focus here was on offshore wind energy exclusively. Ultimately, this does not result in a complete picture. Cumulative effects were calculated for offshore wind but not for other activities and other interventions, or for those species for which, given past experience, the largest impact is expected.

The summaries and assessments below are based on the *public* knowledge and insights currently available (in early 2019). Changing insights in the future, for example as a result of new research, new models or new policy, could lead to changes in the outcomes in this KEC. That will result in another update of this KEC. The present Report C describes the changes compared with the previous KEC (2016) for the four subprojects (Bird Collisions, Bird Habitat Loss, Bats and Harbour Porpoise Underwater Sound). In addition, summaries and conclusions are stated for the differents subprojects.

2 New scenario for the roll-out of offshore wind energy in the period leading up to 2030

2.1 Research area

When determining which existing and future wind farms and wind farms planned in the period leading up to 2030 should be included in the scenario for the KEC 3.0, the biogeographical regions of birds and bats were taken into account (see Figure 2). This means the southern North Sea. That choice was based primarily on the characteristics of the area and the functions it has for the relevant species. This area is a relatively shallow (predominantly less than 200 m deep), warm and sheltered part of the North-East Atlantic region.

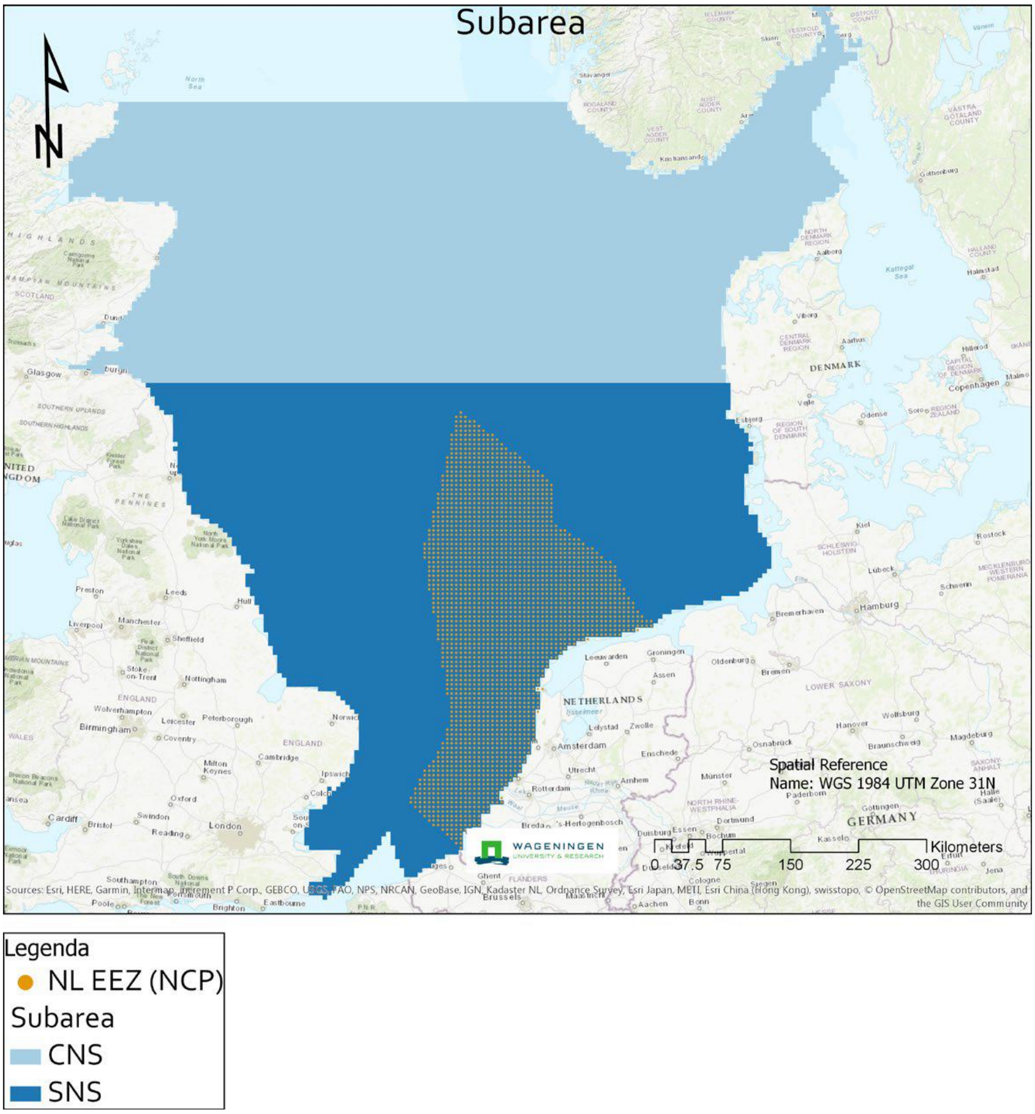

Figure 2 The study area for birds and bats. The national scenario is the DCS. The international scenario is the southern North Sea (SNS) + central North Sea (CNS) and it includes the DCS (=NCP in figure 2).

For underwater sound and the effects on harbour porpoises, use is made of the management units defined by ICES at the request of the European Commission and the OSPAR Commission (see Figure 3).

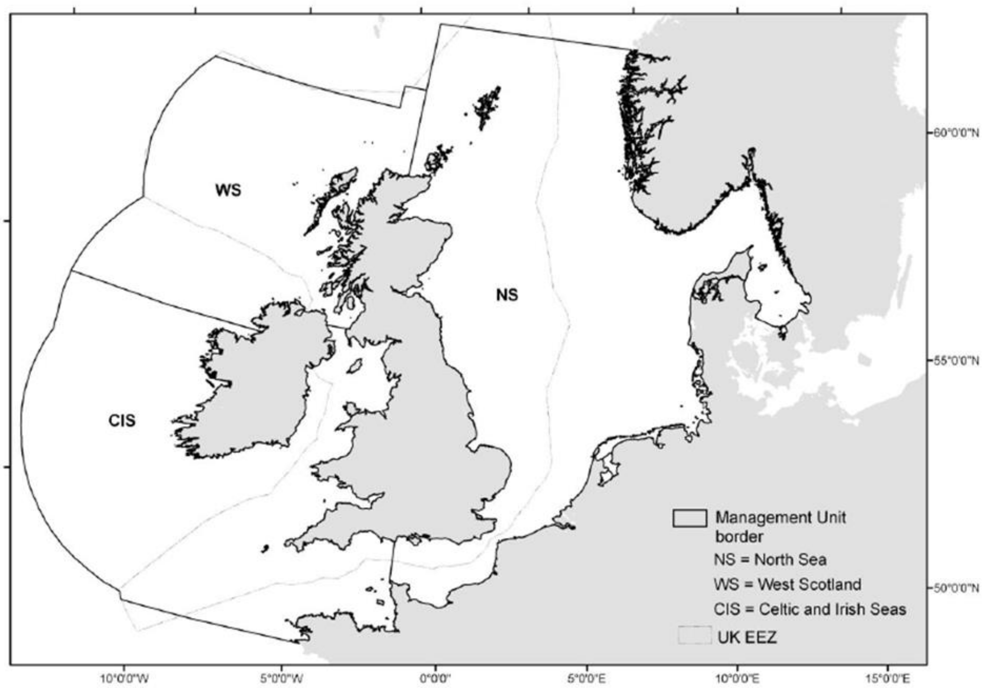

Figure 3 **Study area for harbour porpoise**

2.2 Scenario for wind farms in the period leading up to 2030

The 2030 Offshore Wind Energy Roadmap was published in March 2018. In addition to the wind farms to be built through to 2023, this includes the planning, size and location of the wind farms at sea through to 2030. This is the 'national scenario'.

This roadmap provides for wind farms from 2024 onwards with a combined size of approximately 6.1 GW. The areas in question are:

- Hollandse Kust (west) with a capacity of 1.4 GW; operations are expected to begin in 2024-2025;
- Ten Noorden van de Waddeneilanden with a capacity of 0.7 GW; operations are planned to begin in 2026;
- IJmuiden Ver, the largest wind energy area with approximately 4.0 GW; operations will begin in the period 2027-2030.

The offshore wind energy roadmap provides for a minimum of 3.5 GW (in 2023) and 6.1 GW (in 2030) on top of the existing wind farms (1 GW).[5] Together, therefore, this represents a minimum of 10.6 GW. This KEC 3.0 (2019) calculates the installed capacities as described in bullets 1 to 3.

A factor relevant for the calculation of the 2030 Roadmap by comparison with the 2023 Roadmap is that the new Dutch farms will be built further offshore, and that it has been assumed for this KEC that they will be built with at least 10 MW of turbine capacity.

[5] https://zoek.officielebekendmakingen.nl/kst-33561-42.html (in Dutch)

Alongside the Dutch wind farms built in the period leading up to 2030, there are also many advanced international plans and projects for wind farms. The latter have been listed and described in the relevant reports in Part B in the 'international scenario'. The international scenario therefore consists of the Dutch farms and the foreign farms. There are some minor differences between the international scenarios as used in reports in Part B on underwater sound and harbour porpoises, bird collisions and habitat loss as it affects birds. These differences are due to variations in the times when the various subprojects began and the response of the foreign partners to the assessment of the scenarios of the country concerned. They do not affect the final picture.

3 Acceptable limits

3.1 Birds and bats: Potential Biological Removal (PBR)

The reference measure used in the assessment of, among other things, habitat loss is Potential Biological Removal PBR. It calculates - on the basis of the population size of the species concerned, population status and recovery capacity - the number of victims the population can cope with on an annual basis without being endangered. To determine the PBR for each species, this study adopted a population size based on the numbers of seabirds that are determined using processed the seabird density maps. A relative PBR was then calculated (see van der Wal *et al*. 2018). The population size, the number of victims calculated and the PBR cannot therefore be viewed and/or used separately: doing so results in a distorted picture. The national scenario is linked to the scale level of the Dutch Continental Shelf (DCS) and the international scenario to the scale level of the international areas of the North Sea. The local mortality due to habitat loss (in the case of birds) or collisions (for birds and bats) caused by wind farms in the study area is therefore compared with the local populations of the seabirds (and bats, if possible) based on the numbers at sea counted in the study area. The use of PBR as an acceptable measure has been criticised (for example by O'Brien *et al.* 2017) for not being sufficiently cautious. However, as yet, there is no adequate alternative. Until that is the case, PBR will be used cautiously.

3.2 Ecological standard for harbour porpoises in relation to the ASCOBANS agreement

The most relevant question when assessing the consequences of impulsive underwater sound for harbour porpoises as a result of the construction of the wind farms is whether it endangers the conservation status of the population. Calculations by Scheidat *et al.* (2013) show that, according to the PBR method, the threshold of acceptable mortality for the DCS is 272 animals/year for all activities. However, this value refers to direct mortality and does not take into account the possible indirect effect of reduced reproduction. In order to set acceptable limits for the effects on marine mammals, it is important for the conservation status of harbour porpoises on the DCS to be assessed as unfavourable-inadequate (Camphuysen & Siemensma 2011). On the basis of the interim recommendations of the Netherlands Commission for Environmental Assessment on the draft EIA for sites I and II of the Borssele wind energy area, it has therefore been decided that the harbour porpoise population must not decline below 95% of the current population after the construction of offshore wind farms. A further requirement is that there must be a high level of certainty (95%) that the population will not decline further as a result of the construction of the wind farms. On the basis of the data from Geelhoed *et al.* (2011, 2014), it has been estimated that the population on the DCS consists of 51,000 animals (Scheidat, personal communication). This means that the total population should exceed 48,450 animals.

Under the Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS), the interim target that has been set for harbour porpoises is that the population should not fall below 80% of the carrying capacity. It is not known what this capacity is on the DCS. Maintaining the population with a high degree of certainty (95%) at a minimum of 95% of its current size in the context of the construction of offshore wind farms for the entire period 2016 - 2030 can be considered a safe choice.

4 Bird collisions

KEC 1.1 (2015) calculated the number of collision victims for all future wind farms in the southern North Sea (Rijkswaterstaat 2015). In the context of these calculations, all wind farms were then 'filled' with a standard 3 MW turbine rather than the turbines actually planned. When this KEC 3.0 (2019) was drawn up, this development towards higher MWs per turbine was continued and it is assumed that there will be 10 MW turbines in the construction period 2023 - 2030. The numbers of collision victims were then assessed using the Potential Biological Removal (PBR) for the relevant population of the species in the southern North Sea.

Since the completion of the KEC 1.1 study (Rijkswaterstaat 2015), new knowledge has become available about the flight behaviour of birds in wind farms and flight paths across the North Sea and that information has been incorporated in the new calculations for this KEC 3.0 (2019). In addition, the proposed developments from the 2030 Roadmap are further offshore and this will affect densities (densities for some species will be lower) and therefore the calculations.
The Band model (Band 2012) was used in the KEC 3.0 (2019) to calculate the number of collision victims (A. Gyimesi *et al.* 2018).

The ten bird species were considered that reached the highest fraction of the PBR for collision victims in KEC 1.1 (2015).
The species considered are:

Seabirds:
1. Great Black-backed Gull
2. Lesser Black-backed Gull
3. Herring Gull
4. Black-legged Kittiwake
5. Great Skua

Migratory birds:
1. Bewick's Swan
2. Brent Goose
3. Common Shelduck
4. Curlew
5. Black Tern

4.1 Changes compared with KEC 1.1 (2015) and 2.0 (2016) for bird collisions

There have been a number of changes compared with the previous KEC bird collisions:
- Wind farm plans have been updated in line with the latest knowledge;
- Wind turbine sizes in these calculations are wind farm-specific rather than a worst-case scenario of 3 MW in each wind farm. The wind farm-specific sizes of turbines come from the planning schedules; the wind farms in the Dutch situation have been estimated at 10 MW for 2023-2030;
- Count data for the period 2014-2017 have been added to the densities of seabirds;
- Densities of seabirds for the national scenario were determined over the period 2000-2017 instead of 1991-2014 to improve reliability;
- The international ESAS and Dutch MWTL count data for the southern and central parts of the North Sea over the period 1991-2017 were used for seabird density calculations in the international scenario;
- The population size was determined on the basis of density maps, with the sum of the long-term averages of all six seasons being adopted as the virtual population size (van der Wal *et al*. 2018);

- Data on the flight behaviour of the Lesser Black-backed Gull and Herring Gull have been updated on the basis of the study by Gyimesi *et al.* (2017a) in the WOZEP;
- Data on flight behaviour and migration routes of the Bewick's Swan and Brent Goose have been updated on the basis of the study by Gyimesi *et al.* (2017b) in the WOZEP;
- Fluxes for the Common Shelduck, Curlew and Black Tern have been updated on the basis of population developments since the KEC 1.1 study (cf. BirdLife International 2004, 2015);
- In PBR calculations, seabird population sizes were determined using the same density maps as the input for the victim calculations. These numbers can therefore not be taken separately;
- In PBR calculations, values for recovery capacity were adjusted in line with the latest conservation status classification by IUCN (IUCN 2018);
- In PBR calculations, population sizes or migratory birds were updated on the basis of population developments since the KEC 1.1 study (cf. BirdLife International 2004, 2015).

4.2 Conclusions relating to bird collisions

The numbers of seabird collision victims were calculated for the international situation and for the national situation. Calculations were made for migratory birds for the international situation only: there are no density data for migratory birds above the sea and so it was not possible to determine a Dutch population.

Table 1: Percentage of seabird victims compared with the PBR as a result of collisions with wind turbines in existing and future wind farms in the central and southern North Sea for both the central and southern North Sea populations.

Species	**Scientific name**	**National % PBR (2030)**	**International % PBR (2030)**
Great Skua	*Stercorarius skua*	0.6%	0.3%
Northern Gannet	*Morus bassanus*	1%	1%
Black-legged Kittiwake	*Rissa tridactyla*	10%	15%
Great Black-backed Gull	*Larus marinus*	7%	7%
Lesser Black-backed Gull	*Larus fuscus*	22%	21%
Herring Gull	*Larus argentatus*	48%	33%

Table 2: Percentage of migratory bird victims compared with the PBR as a result of collisions with wind turbines in existing and future wind farms in the central and southern North Sea ??stated as a fraction of the PBR for the ***flyway population****. Population sizes were determined using population estimates (BirdLife International 2004 and 2015) and current population trends (IUCN 2018).*

Species	**Scientific name**	**International % PBR (2030)**
Bewick's Swan	*Cygnus bewickii*	8%
Brent Goose	*Branta bernicla*	1%
Common Shelduck	*Tadorna tadorna*	10%
Curlew	*Numenius arquata*	64%
Black Tern	*Chlidonias niger*	98%

The largest knowledge gap relates to the following migratory birds: Black Tern, Curlew and Common Shelduck. Knowledge is lacking for these species about migration routes and flight behaviour at sea. It was therefore possible to make only broad assumptions in the Band model calculations: for example that these species can be found in any wind farm in the central and southern North Sea. There is also a knowledge gap with respect to the percentage of birds flying at rotor height. New information relating to these knowledge gaps could lead to an improvement in the calculated numbers of victims.

OWEZ and PAWP are not included in the study. A supplementary memorandum was drafted for this purpose that discusses the effects of OWEZ and PAWP in terms of collisions (Gyimesi & Leemans 2018) (part of KEC 3.0 Part B). After the inclusion of PAWP and OWEZ, the victim percentages did not exceed the PBR.

The general conclusion for bird collisions as a result of offshore wind energy is that, for seabirds and with regard to the Dutch population (insofar as there is a Dutch population), there is no exceedance of the PBR as a result of the Dutch wind farms (PBR remains well below 100%, which is a good thing from the point of view of the precautionary principle). It is difficult to determine which migratory bird victims can be attributed to the Dutch wind farms. The international PBR for migratory birds continues to be below 100%. The Curlew and the Black Tern are a concern with respect to migratory birds. Research will need to focus more specifically on this area.

5 Habitat loss for birds

This report updates 'A first approach to deal with cumulative effects on birds and bats of offshore wind farms and other human activities in the Southern North Sea' (Leopold *et al.* 2014) for habitat loss affecting birds in response to the '2030 Roadmap for Offshore Wind Energy', which includes the location of offshore wind farms in the period leading up to 2030.

For this KEC 3.0 (2019) ('Cumulative effects of offshore wind farms: loss of habitat for seabirds. Update for five seabird species until 2030', J.T. van der Wal, M.E.B. van Puijenbroek, M.F. Leopold, WMR 2018), a calculation was made of the habitat loss affecting five seabird species (Divers, i.e. Red-throated and Black-throated divers (taken together but in the knowledge that >90% of the species are Red-throated Divers), Northern Gannet, Sandwich Tern, Common Guillemot and Razorbill) that may occur as the result of the ongoing development of wind farms in the southern and northern North Sea in both a national context (Dutch EEZ or DCS: national scenario) and an international context (international scenario).

Using the Relative Displacement Score from the extended Bradbury method as elaborated in Leopold *et al*. (2014), the step is made from affected seabirds to expected additional mortality as a result of habitat loss. This modelled mortality is compared with the reference measure Potential Biological Removal (PBR).

5.1 Changes compared with KEC 1.1 (2015) and 2.0 (2016) for bird habitat loss

There have been some changes compared with the previous KEC for bird habitat loss, mainly with regard to data processing:

- Wind farm plans have been updated in line with the latest knowledge;
- Count data for the period 2014-2017 have been added to the densities of seabirds;
- Densities of seabirds for the national scenario were determined over the period 2000-2017 instead of 1991-2014 to improve reliability;
- The international ESAS and Dutch MWTL count data for the southern and central parts of the North Sea over the period 1991-2017 were used for seabird density calculations in the international scenario;
- The population size was determined on the basis of density maps, with the sum of the long-term averages of all six seasons being adopted as the virtual population size (van der Wal *et al*. 2018);
- In PBR calculations, seabird population sizes were determined using the same density maps as the input for the victim calculations. These numbers can therefore not be taken separately;
- In PBR calculations, values for recovery capacity were adjusted in line with the latest conservation status classification by IUCN (IUCN 2018).

The calculations used the method adopted in the Leopold *et al.* (2014) report and no changes have been made in this respect.

5.2 Conclusions relating to bird habitat loss

Nationally, the Razorbill (*Alca torda)* is the species with the highest proportion of victims in relation to the PBR, followed by the Common Guillemot (*Uria aalge*). Internationally, these two species are also the ones that are particularly affected, with Divers (*Gavia* spec.) occupying third position.

Table 3: Percentage of victims by comparison with PBR for the various seabird populations due to habitat loss, reference year 2030

Species	Scientific name	National % PBR (2030)	International % PBR (2030)
Divers	*Gavia* spec.	0.4%	4.1%
Northern Gannet	*Morus bassanus*	0.7%	0.7%
Sandwich Tern	*Thalasseus sandvicensis*	0.9%	1.6%
Common Guillemot	*Uria aalge*	3.8%	5.1%
Razorbill	*Alca torda*	23.1%	26.7%

With regard to the farms that have already been built and that are still to be built on the DCS, the analysis shows that the impact on three of the five species studied in terms of mortality as a result of habitat loss is relatively small. The Razorbill and the Common Guillemot suffer more losses due to mortality as a result of habitat loss (up to 23% of the PBR for Razorbills in 2030, and up to 4% for Guillemots; less than 1% for the other three species).

Internationally, the percentages are higher, with the value being highest for the Razorbill (up to 27% of the PBR). The locations of the British farms in particular overlap with areas with quite high densities of Common Guillemots and Razorbills. The Divers are affected most severely by the developments in Germany.

The general conclusion for bird habitat loss is that the number of victims remains below the PBR both nationally and internationally (PBR is well below 100%, which is good from the point of view of the precautionary principle).

6 Bats

During late summer and autumn, Nathusius's pipistrelles (*Pipistrellus nathusii*) migrate from the Baltic States and Russia to Western Europe to mate and hibernate. Some of these bats cross the North Sea on their way to the United Kingdom, where they may encounter offshore wind farms. It is known that the moving rotor blades of wind turbines cause mortality in bats. This mortality rate is likely to increase because the total capacity of Dutch offshore wind farms is expected to increase until 2030 and beyond.

On the basis of KEC 1.1, a requirement was included in the site decisions in 2015 on the basis of the time of year and wind speed. Since 2015, a considerable amount of new information on bat activity in the Dutch offshore wind farms has been collected using approaches such as acoustic monitoring (bat detectors). The report 'Mitigating measures for bats in offshore wind farms. Evaluation and improvement of curtailment strategies', M. Boonman, Bureau Waardenburg, 2018, was drawn up for KEC 3.0 (2019).

Because the bandwidth for the estimated population size of Nathusius's pipistrelles migrating across the North Sea is large (100 - 1,000,000; Limpens *et al.* 2017), it is not possible to calculate a PBR for bats for the 2030 Roadmap.

With the new information and knowledge acquired in recent years, the requirement has been evaluated with the aim of answering the specific question of whether this requirement can be made more efficient without mitigation being affected. The aim was to reduce both the mortality rate and losses of energy production.

6.1 Changes compared with KEC 1.1 (2015) and 2.0 (2016) for bats

The current curtailment strategy is as follows (https://wetten.overheid.nl/BWBR0040532/2017-11-08/):
'… A measure was therefore chosen where the cut-in wind speed of the turbines shall be increased to 5.0 m/s at tower height during the period from 15 August to 30 September between 1 hour after sunset and 2 hours before sunrise. Below this wind speed the number of rotations per minute per wind turbine shall be reduced to less than 1.'

Since the previous KEC, more and better information has become available relating to the presence of bats and the associated conditions. These were considered during the evaluation of the current curtailment arrangement. The measure can be made more effective by using the new knowledge. An incidental effect is that there is less loss of production.

6.2 Conclusions for bats

The advice is to draw up new requirements for the Hollandse Kust and Borssele areas in the 2030 Roadmap, taking into account the latest insights with regard to bat presence in relation to the weather.
By comparison with the existing requirements, this new strategy results, in the case of a modern wind turbine, in a 12% reduction in the loss of energy production and a significantly lower risk of fatalities (from an expected 25% less mortality to 40% less mortality, an improvement of 15 percentage points). A larger reduction in the number of victims than 40% can almost only be achieved by further raising the cut-in wind speed. This leads to a disproportionate loss of energy production.

The new requirements include the following:

- Time of year: from 25 August to 10 October;
- Time of day: all night from sunset to sunrise;

- Weather: inclusion of the wind direction, wind speed and temperature in line with Table 4;
- Change in cut-in speed: increase the cut-in speed in line with Table 4.

Table 4: Optimal curtailment strategy. The cut-in wind speed is displayed for each combination of temperature (left vertical) and wind direction (top horizontal).

T(C)	N	NNE	NEE	E	SEE	SSE	S	SSW	SWW	W	NWW	NNW
<11	3	3	3	3	3	3	3	3	3	3	3	3
11-15	3.5	4.5	5.5	6	5.5	5.5	3.5	3.5	3.5	3	3	3
15-17	3.5	4.5	5.5	6	5.5	5.5	4.0	3.5	3.5	3	3	3
17-19	3.5	4.5	5.5	6	5.5	5.5	4.0	3.5	3.5	3	3	3
>19	3.5	4.5	5.5	6	5.5	5.5	4.0	3.5	3.5	3	3	3

The following recommendations have also been made:

- Regulation of wind farms using measurements in the last time interval: use of a time interval of 20 minutes;
- Regulation for individual wind turbines: for the time being, regulation for individual wind turbines (measurement from the nacelle). However, regulation for individual wind turbines will have to be evaluated in order to prevent an increase in the number of bat victims.

The new insights, table and recommendations above will be further elaborated and coordinated in the site decisions and the working plans for the site decisions.

7 Underwater sound and porpoises

For the KEC 1.1, a staged approach (the staged procedure) was used to calculate the effects of pile-driving for the construction of the wind farms in the Energy Agreement on the harbour porpoise population on the DCS. These effects have been described in the report 'Cumulative effects of impulsive underwater sound on marine mammals' (Heinis *et al.* 2015). Based on the insights at that time, it was calculated that the population decline would exceed the acceptable limit. In the KEC 2.0 (2016), the results of site-specific calculations for the Borssele wind energy area led to the conclusion that significant negative effects can be prevented only if mitigating measures are taken to reduce sound during construction.

For the KEC 3.0 (2019), the stages in the 2015 staged procedure have been updated on the basis of the most recent knowledge and insights relating to harbour porpoises. Following this update, the effects of the construction of offshore wind farms on the harbour porpoise population for the period 2016-2030 were calculated for a number of Dutch scenarios as well as for an international scenario. On the basis of the results of these calculations, a sound standard was derived for the wind farms to be constructed in the period leading up to 2030 that were not included in the Energy Agreement. The results of the study can be found in the report 'Framework for Assessing Ecological and Cumulative Effects - 2018: Cumulative effects of offshore wind farm construction on harbour porpoises' (Heinis *et al.* 2018).

7.1 Changes compared with KEC 1.1 (2015) and 2.0 (2016) for underwater sound and harbour porpoises

The effects of the construction of offshore wind farms on the harbour porpoise population have been calculated for both the KEC 1.1/2.0 and the KEC 3.0 (2019) using the following staged approach:

1. The calculation of a realistic worst case in the propagation of sound due to a single strike for each wind farm; this calculation is based on information about the source strength, local factors (including bathymetry and bed structure) and knowledge about how sound propagates in water;
2. The calculation of the size of the area disturbed by impulsive sound for each wind farm. This is determined by the calculated sound propagation and a threshold value for the occurrence of a significant behavioural change;
3. The calculation of the number of harbour porpoises disturbed by sound on the basis of the calculated disturbed areas multiplied by the local density of harbour porpoises by season;
4. The calculation of the number of harbour porpoise disturbance days on the basis of the number of disturbed animals per day multiplied by the number of disturbance days;
5. The estimation of the possible impact on the population using the iPCoD model;
6. The assessment of the estimated population reduction and appraisal with reference to the ecological target set by the government (see Section 3.2).

For KEC 3.0 (2019), the following changes have been made to the stages compared with KEC 1.1/2.0:

- Stage 1: To calculate sound propagation, the Aquarius 4 model developed in the context of the WOZEP was used rather than the Aquarius 1.0 model previously used. The use of the Aquarius 4 model results in more reliable calculation results that are a better match for the sound levels (broadband and otherwise) measured in the field (de Jong *et al.* 2018).
- Stage 2: No fundamental changes, except that, in addition to the disturbance threshold used in the past of 140 dB re 1 $\mu Pa^2 s$, disturbance areas were also

calculated for a disturbance threshold of 143 dB re 1 μPa^2s. However, for the derivation of new sound standards, the threshold value used in the past of 140 dB re 1 μPa^2s was used in line with the worst-case approach;
- Stage 3: More recent data on local harbour porpoise densities were adopted such as SCANS III (Hammond *et al.* 2017);
- Stage 4: No changes;
- Stage 5: For the 2018 KEC, the effects of disturbance by impulsive sound have been stated as an effect on the harbour porpoise population using version 5 of the Interim PCoD model. This is a full update of the previous version 2.1 based on the 2013 expert elicitation. Version 5 incorporates the results of the expert elicitation workshops in February and June 2018. During the workshop in June, it emerged that the effects of disturbance on vital rates resulting from piling sound were thought to be considerably smaller than those noted during the expert elicitation in 2013, which was conducted in writing;
- Stage 6: In principle, KEC 3.0 (2019) is based on the same ecological standard as KEC 2.0 (2016). This means that the population decline estimated with a high degree of certainty as a result of the construction of wind farms on the DCS in the period through to 2030 may not exceed 5% (and that it must preferably be less) and therefore that there must be a high level of certainty that the population must be maintained at a minimum of 95% of its current size.

New scenarios were developed for KEC 3.0 (2019) for calculating the effects on the harbour porpoise population of the construction of offshore wind farms in the period 2016 - 2030, including the wind energy areas Hollandse Kust (west), Ten Noorden van de Waddeneilanden and IJmuiden Ver. In addition, calculations were made for an international scenario that was updated by comparison with KEC 1.1, with the prevailing sound standards being used for those countries that have sound standards. By contrast with the previous calculations, the Dutch scenarios also take into account the possible effects of the construction of the transformer platforms and the geophysical surveys for both the offshore network and the wind farms needed to determine the characteristics of the seabed in the wind energy area and on the cable routes.

7.2 Conclusions on underwater sound and harbour porpoises

It emerges from the results of the calculations that the sound standards for the construction of the wind farms after 2023 may be higher than those for the wind farms in the Energy Agreement. This is partly due to the fact that a new version of the Interim PCoD model was used to calculate the effects on the harbour porpoise population that included the results of an expert elicitation workshop organised in June 2018 about the effects of disturbance by impulsive sound. Calculations used in this model result in a population reduction that is 3 to 6 times less than the reduction calculated with the earlier version – version 2.1 – of the Interim PCoD model.

A sensitivity analysis of the consequences of different choices for the level of a sound standard to be imposed for the ecological standard shows that, even with the most flexible ecological standard, *i.e*. a maximum permissible reduction of the harbour porpoise population by 2,550 animals by 2030, some form of sound mitigation is necessary. The following factors determine the selection of a sound standard, whether differentiated or not:

1. Ecological standard: What reduction in the harbour porpoise population as a result of the construction of wind farms in the period 2016 - 2030 is still acceptable?
2. Seasonal variation in harbour porpoise density;

3. Differences in disturbance areas between areas due to differences in water depth;
4. Number of foundations to be piled per wind farm/site.

With regard to 1. It emerged from the calculations that a more flexible sound standard can be used during the construction of the wind farms after 2023. The sound standard to be applied depends on the ecological standard selected. In order to ensure that developments in wind energy remain possible after 2030 and to maintain ecological latitude for other activities that produce sound, the policy decision has been made to adopt an ecological standard of a maximum of approximately 1,000 animals (with a 95% certainty).

With regard to 2. In the KEC 1.1/2.0 (2015/2016), the sound standards to be applied depended on, among other things, the season in which the activities would take place because of assumed seasonal differences in the harbour porpoise density. More recent data about numbers of harbour porpoises in the North Sea indicate that these differences are probably not as large. It was therefore decided not to impose any more seasonal sound standards for the construction of wind farms after 2023.

With regard to 3. In order to comply with a certain ecological standard, the sound standard to be imposed in the wind farm Ten noorden van de Waddeneilanden must be stricter than in the wind farms off the Dutch coast because the water is deeper here. However, for the time being, it has been decided not to differentiate by wind energy area and to use a single uniform sound standard for all areas. This therefore means that a larger effect is permitted locally and that it will be compensated by smaller effects in other, shallower, areas.

With regard to 4. The trend towards wind turbines with larger capacities is continuing. Whereas KEC 2.1 still assumed 6 MW wind turbines, the calculations for the wind farms after 2023 were made for 10 MW wind turbines (this is not the case in the KEC 2.1 for birds). To achieve the same maximum installed capacity, fewer wind turbines are therefore needed and the number of days on which there is pile-driving is also lower. In principle, this results in fewer large effects on harbour porpoises at comparable sound levels (in other words, fewer harbour purpose disturbance days). This is an additional argument in favour of a more flexible sound standard than is found in the draft site decisions for the wind farms in the Energy Agreement.

If a single universal sound standard is assumed of SELss (750 m) = 168 dB re 1 μPa^2s for the construction of the wind farms after 2023 using 10MW wind turbines and the sound standards set out in the site decisions for the wind farms planned in the Energy Agreement, the probability is higher than 95% that the harbour porpoise population on the DCS will decline by no more than 865 animals (= approx. 1.7% of the population on the DCS), a percentage that is well within the limit of the standard described in Section 3.2.

8 Final conclusion on the roll-out of offshore wind energy in the period leading up to 2030

With regard to the effects of the new offshore wind farms on birds and marine mammals, the combined ecological effects of all offshore wind farms in the period leading up to 2030 have been described in this Framework for the Assessment of Ecological and Cumulative effects.

The existing regulations have been evaluated for bats. For the time being, the expected effects after mitigation are still within the limits of the Nature Conservation Act, in part due to larger turbines (10 MW) and the selection of wind energy areas a long way offshore in the 2030 Roadmap. Studies from the offshore wind energy ecological programme funded by the Dutch Ministry of Economic Affairs and Climate (WOZEP[6], Parliamentary Proceedings 33 561, no.: 1) have also contributed to further reducing uncertainties in the assumptions. Changing insights in the future, for example as a result of new research, new models or new policy, may lead to changes in the outcomes in this KEC.

Parts B and C look at the activity of offshore wind energy and not at other activities and interventions. By assuming the precautionary principle and prescribing realistic but sound mitigation measures, latitude is maintained for other activities and for future developments (even though these have not yet been further specified).

[6] https://zoek.officielebekendmakingen.nl/kst-33561-26.html (in Dutch) and https://www.noordzeeloket.nl/en/functions-and-use/offshore-wind-energy/

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